B-W NO 205-8000
0142-0427P
Westdijk et al
August 22, 2003
1 of 1

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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

02078501.0

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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R C van Dijk

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THE HAGUE, 17/02/03
LA HAYE, LE

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Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

Anmeldung Nr.:
Application no.:
Demande n°:
02078501.0

Anmeldetag:
Date of filing:
Date de dépôt:
22/08/02

Anmelder:
Applicant(s):
Demandeur(s):
Océ-Technologies B.V.
5914 CC Venlo
NETHERLANDS

Bezeichnung der Erfindung:
Title of the invention:
Titre de l'invention:
Printing device and control method thereof

In Anspruch genommene Prioriät(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

Staat: State: Pays:	Tag: Date: Date:	Aktenzeichen: File no. Numéro de dépôt:

Internationale Patentklassifikation:
International Patent classification:
Classification internationale des brevets:

/

Am Anmeldetag benannte Vertragstaaten:
Contracting states designated at date of filing:
Etats contractants désignés lors du depôt:
AT/BG/BE/CH/CY/CZ/DE/DK/EE/ES/FI/FR/GB/GR/IE/IT/LI/LU/MC/NL/

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Océ-Technologies B.V., of Venlo

PRINTING DEVICE AND CONTROL METHOD THEREOF

FIELD OF THE INVENTION

The present invention is related to a printing device such as a printing or copying system employing multiple print heads containing discharge elements for image-wise forming dots of a marking substance on an image-receiving member. Examples of such printing devices are inkjet printers and toner-jet printers. Hereinafter reference will be made to inkjet printers.

BACKGROUND OF THE INVENTION

Print heads employed in inkjet printers and the like usually each contain a plurality of discharge elements arranged in (a) linear array(s) parallel to the propagation direction of the image-receiving member (typically paper) or in other words the sub scanning direction. The discharge elements usually are placed substantially equidistant. In operation, the discharge elements are controlled to image-wise discharge ink droplets on an image-receiving member such as to form columns of image dots of ink in relation to the linear arrays. The discharge activation may be thermally or thermally assisted and/or mechanically or mechanically assisted and/or electrically or electrically assisted, including piezoelectrically. In scanning inkjet printers, the print heads are supported by a print carriage which is movable across the image-receiving member, i.e. in the direction perpendicular to the propagation direction of the image-receiving member or in other words the main scanning direction. In operation a scanning inkjet printer forms a matrix of image dots of ink corresponding to a part of an image by scanning the print heads at least once, optionally bi-directionally, over the image-receiving member in the main scanning direction. After a first matrix is completed the image-receiving member is displaced such as to enable the forming of the next matrix. This process may be repeated till the complete image is rendered.

When multiple print heads are employed, due to small deviations between the print heads, including e.g. dimensional variations, variations in the control of the print heads, and variations in the visco-elastic properties of the ink, the size of image dots resulting from distinct print heads may vary on the image-receiving member. Examples of dimensional variations are differences in nozzle shape or size, differences in the

shape or size of the ducts connecting the ink reservoirs with the respective nozzles. These differences may be introduced by the manufacturing process or may arise during extended use e.g. caused by contamination of the ink. An example of a variation in control is e.g. a small deviation in amplitude, shape or timing of the stimulus initiating the discharge of a discharge element. Any variation in an output parameter of distinct print heads such as e.g. the ink dot size, or the optical density of the image formed, or dot positioning, may cause visual disturbances in the image formed. These disturbances are particularly annoying when the distinct print heads discharge ink of the same colour. Such variation may be attributed to the print head temperature. Besides the small deviations between the print heads, as described above, causing static variations, also dynamic variations between distinct print heads may arise, e.g. because of differences in coverage of the image parts which are to be reproduced by the distinct print heads.

In US 6,283,650 a method is disclosed for controlling output levels of an inkjet printer having multiple print heads. Specifically, a dynamic print head temperature control method is disclosed wherein a predetermined relationship between output levels of multiple print heads is maintained by controlling the relative temperature differences between the print heads. To enable this, based on the obtained temperature of an arbitrary one of the multiple print heads, initial target temperatures for each other of the multiple print heads are determined. When printing, these target temperatures are dynamically adjusted in order to maintain the predetermined relationship between the output level of the one of the multiple print heads and the output level of each other of the multiple print heads.
A disadvantage of the approach as disclosed in US 6,283,650 is that in order to maintain the predetermined relationship in output level, the relative temperature differences between distinct print heads should be that high that the proper functioning of individual print heads is hampered because the target temperature value of the print head is too low or too high. Particularly, when the temperature of a print head is too high a severe deterioration of the print quality may occur due to the increase in dot size and/or the failure of individual discharge elements due to contamination, while when the temperature of a print head is too low a severe deterioration of the print quality may occur due to the decrease in dot size and/or the failure of individual discharge elements due to the destabilisation of the discharge process. A further disadvantage of the approach as disclosed in US 6,283,650 is that the control, drive and sensing means required to implement such a dynamic control are complex and costly. In operation, the

temperature of the print heads rapidly and gradually increases which differently effects an output level of the distinct print heads. According to the approach as disclosed in US 6,283,650, the temperature of each print head needs to be accurately sensed and fed back to a controller which responsive thereto, after consulting predetermined target temperature tables, needs to adequately adjust the temperature of each of the distinct print heads to maintain a predetermined relationship in output level. To be effective, a sufficiently fast rate temperature adjustment is required, or in other words the time interval between two subsequent adjustments should be small, and the adjustment time should be sufficiently small in order to obtain a more or less continuous temperature adjustment. This is particularly challenging when a print head needs to be cooled to obtain its target temperature.

OBJECTS OF THE INVENTION

It is an object of the invention to provide a printing device and method which obviates the need to dynamically control relative temperatures of distinct print heads by minimising the influence of output parameter initiated relative temperature variations. Particularly, by minimising static temperature corrections for the distinct print heads, the influence of dynamic relative temperature variations is minimised.

It is a further object of the invention to execute minimal static temperature corrections for each of the print heads of a printing device having multiple print heads in relation to a target value of an output parameter of said print heads. Particularly, the temperature correction should be such that the obtained target temperature for each of the distinct print heads differs maximum 15% from the temperature value associated with the target value of the output parameter.

SUMMARY OF THE INVENTION

In a first aspect of the invention a printing device is disclosed having a plurality of print heads for image-wise forming dots of a marking substance on an image-receiving member, comprising:

a heat exchange device for bringing the temperature of each of said plurality of print heads to a predetermined temperature value, and

an adjustment device for adjusting the temperature of one or more of said plurality of print heads from its predetermined temperature value to an associated target temperature value,

characterised in that

each of said associated target temperature values is determined in relation to a target value of an output parameter of said print heads, said target value of said output parameter being determined on the basis of the respective values of said output parameter for the respective print heads, said respective values being obtained by operating each of said respective print heads at said predetermined temperature value to render a predetermined test pattern, where said target value of said output parameter is determined such that for each of the print heads the absolute value of the difference between said associated target temperature value and said predetermined temperature value with which the temperature of each print head is to be adjusted is 15% of said predetermined temperature value or less. Preferably, to minimise adjustment time, the absolute value of the difference between the associated target temperature value and the predetermined temperature value with which the temperature of each print head is to be adjusted is 10% of the predetermined temperature value or less. Any marking substance can be used provided it can be discharged in fluid form, including e.g. ink. The image-receiving member may be an intermediate member or a medium. The intermediate member may be an endless member, such as a belt or drum, which can be moved cyclically. The medium can be in web or sheet form and may be composed of e.g. paper, film, cardboard, label stock, plastic or textile.

Further according to the present invention, in order to minimise the differences between the target temperature values of the respective print heads and the predetermined temperature value, the target value of said output parameter is obtained by averaging the respective values of the output parameter for the respective print heads. In an embodiment of the invention, the target value of the output parameter is obtained by selecting the median value of the respective values of the output parameter for the respective print heads.

In another embodiment of the present invention, the printing device comprises at least two print heads for image-wise forming dots of marking substance of the same colour. These at least two print heads may be positioned on the print carriage in any configuration with respect to the main scanning direction including an in-line configuration and a staggered configuration.

In yet another embodiment of the present invention, the printing device comprises

a first plurality of print heads for image-wise forming dots of a first colour and a second plurality of print heads for image-wise forming dots of a second colour different from said first colour, said first plurality of print heads having a corresponding first predetermined temperature value and a first target value of an output parameter, said second plurality of print heads having a corresponding second predetermined temperature value, different from said first temperature value and a second target value of an output parameter.

In another aspect of the invention, a method is disclosed for controlling a printing device having a plurality of print heads for image-wise forming dots of a marking substance on an image-receiving member, the method comprising the steps of:

bringing the temperature of each of said plurality of print heads to a predetermined temperature value,

determining a target temperature value for one or more of said plurality of print heads, and

adjusting the temperature of one or more of said plurality of print heads from its predetermined temperature value to its associated target temperature value, characterised in that

each of said target temperature values is determined in relation to a target value of an output parameter of said print heads, said target value of said output parameter being determined on the basis of the respective values of said output parameter for the respective print heads, said respective values being obtained by operating each of said respective print heads at said predetermined temperature value to render the same image, where said target value of said output parameter is determined such that for each of the print heads the absolute value of the difference between said associated target temperature value and said predetermined temperature value with which the temperature of each print head is to be adjusted is 15% of said predetermined temperature value or less, or 10% % of said predetermined temperature value or less. The target value of said output parameter may be obtained by averaging the respective values of the output parameter for the respective print heads. In that case, a target temperature value for each of the respective print heads is determined, and the temperature of each of the respective print heads is adjusted from its predetermined temperature value to an associated target temperature value. Alternatively, the target value may be the value of the output parameter for the print head having the median output parameter value.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 depicts an example of an inkjet printer.

Figure 2 is a cross-sectional view of a print head of an inkjet printer as in fig.1.

Figure 3 depicts the dot-mass versus the substrate temperature for black coloured ink.

Figure 4 depicts the optical density (OD) versus the substrate temperature for black coloured ink.

Figure 5 depicts the change in optical density per degree centigrade versus the optical density for black coloured ink.

DETAILED DESCRIPTION OF THE INVENTION

In relation to the appended drawings, the present invention is described in detail in the sequel. Several embodiments are disclosed. It is apparent however that a person skilled in the art can imagine several other equivalent embodiments or other ways of executing the present invention, the scope of the present invention being limited only by the terms of the appended claims. In particular, the present invention is not limited to inkjet or toner-jet printers of the scanning type, i.e. printers where the print heads are supported by a print carriage which is movable across the image-receiving member, but is also applicable to printers which do not perform a scanning operation in the main scanning direction. The print heads of these latter type printers may have a width, i.e. the maximal distance between discharge elements of a print head in the main scanning direction, equal to or larger than the width, i.e. the dimension in the main scanning direction, of the image-receiving member.

The printing device of fig.1 is an inkjet printer comprising a roller (1) for supporting an image-receiving member (2) and moving it along four print heads (3) provided with black coloured ink. A scanning print carriage (4) carries the four print heads and can be moved in reciprocation in the main scanning direction, i.e. the direction indicated by the double arrow B, parallel to the roller (1), such as to enable scanning of the image-receiving member in the main scanning direction. Only four print heads are depicted for demonstrating the invention. In practice an arbitrary number of print heads may be employed provided this number is at least two. Other print heads may be added, optionally provided with ink of a different colour, or existing print heads may be removed or replaced by a print head capable of rendering another colour. Colour includes black, white and all shades of grey. The roller is rotatable about its axis as indicated by arrow A. The image-receiving member can be a medium in web or in sheet form and may be composed of e.g. paper, cardboard, label stock, plastic or textile. Alternately, the image-receiving member can also be an intermediate member, endless or not. Examples of endless members, which can be moved cyclically, are a belt or a drum. The carriage (4) is guided on rods (5) (6) and is driven by suitable means (not shown). Each print head comprises a number of discharge elements (7) arranged in a single linear array parallel to the sub scanning direction. Four discharge elements per print head are depicted in the figure, however obviously in a practical embodiment typically several hundreds of discharge elements may be provided per print head, optionally arranged in multiple arrays. As depicted in figure 1, the respective print heads are placed parallel to each

other such that corresponding discharge elements of the respective print heads are positioned in-line in the main scanning direction. This means that a line of image dots in the main scanning direction can be formed by selectively activating up to four discharge elements, each of them being part of a different print head. This parallel positioning of the print heads with corresponding in-line placement of the discharge elements is advantageous to increase productivity and/or improve print quality. Alternatively multiple print heads may be placed on the print carriage adjacent to each other but such that the discharge elements of the respective print heads are positioned in a staggered configuration instead of in-line. For instance, this may be done to increase the print resolution or to enlarge the effective print area, which can be addressed in a single scan in the main scanning direction.

As depicted in figure 2, each discharge element, i.e. the hole in the discharge element plate (20), is connected via an ink duct (21) to an ink supply of the colour of the associated print head. Each ink duct is provided with a transducer, which responsive to a signal can be activated. In figure 2, the transducer is a heater element (22). Electrical connections (23) are provided for connecting the heater element with an associated electrical drive circuit. In operation, an electrical signal activates the heater element, which is in thermal contact with the ink in the ink duct. Responsive thereto an ink bubble is created which is discharged by the discharge element (7) in the direction of an image-receiving member (2) such as to form a dot of ink thereon. Alternatively, instead of a thermal activation of the ink duct, the activation may also be thermally assisted and/or piezoelectrically, or acoustic, or electrostatic. The heater element (22) is separated by an isolating layer (24) from a supporting substrate (25). The isolating layer is a layer with a low thermal and electrical conductance and preferably has a low thermal expansion coefficient. A typical example of such a layer is a SiO_x layer. The supporting substrate (25), which is also in contact with the ink, is preferably composed of a thermally conductive material such as e.g. silicon. The temperature of the print head as referred to in this disclosure is the temperature of the supporting substrate (25). The static temperature of the print head is the temperature of the supporting substrate of said print head at the start of printing. A heat exchange device (not shown) may be provided to bring the temperature of the supporting substrate to a predetermined temperature value. For instance the heat exchange device may comprise one or more heater elements and/or one or more cooling elements in thermal contact with the supporting substrate. The heat exchange device may be in direct contact with the

supporting substrate. The heat exchange device may also be in contact with the ink. An adjustment device (not shown) may be provided to adjust the temperature of the supporting substrate from a predetermined temperature value to a target temperature value. The adjustment device may comprise one or more heater elements and/or one or more cooling elements in thermal contact with the supporting substrate. The heat exchange device may be part of the adjustment device.

Example

A printing device as depicted in Figure 1 is used to reproduce a digital image. A print mode is selected. By selecting a print mode, amongst others a print resolution, a halftoning mask, and a print mask are selected. The print mask contains the information about the number and sequence of printing stages and defines which discharge elements need to be activated, or in other words, contains the information defining for each printing stage which pixels will be rendered by which nozzles such that when all printing stages are completed all the pixels are rendered. A printing stage is a horizontal scanning pass across the image-receiving member in one direction, e.g. from the left to the right, or in other words a scanning pass in the main scanning direction, during which a matrix of image dots is formed. This matrix may be incomplete in case the print mask defines multiple printing stages. Print masks are usually configured such as to minimise the influence of random regional variations in dot size and positioning.

Selecting a printing mode enables the user to exchange image quality for productivity and vice versa dependent on his requirements. Before the actual start of the printing, the temperature of each of the four print heads is brought to a predetermined temperature value of 40 Centigrade degrees by means of a heat exchange device. Said predetermined temperature value may be chosen independent or dependent of the selected print mode. In case the printing device is a multi-colour printing device having multiple print heads per colour, it may be advisable to choose a different predetermined temperature value for each colour in relation to the ink and/or print head characteristics. Moreover in case the selected print mode is such that printing is executed bi-directionally, i.e. when scanning in the main scanning direction both from the left to the right and from the right to the left, said predetermined temperature values may be determined direction dependent. In the latter case, a temperature adjustment may be performed after each printing stage. Such a slow rate temperature adjustment is far less demanding compared to a fast rate temperature adjustment as employed in a dynamic

temperature control process.

Further according to this example, when the predetermined temperature value is reached, a predetermined test pattern is printed on a predetermined image-receiving member, e.g. being a 100 gsm coated paper, by each of the four print heads of the black colour. Suppose said predetermined test pattern is a uniform 50 % coverage black patch. Such a simple pattern is chosen solely for instruction purposes as it allows explaining the invention in a simple way. In practice, the predetermined pattern typically includes a grey-wedge. Due to small deviations between the print heads, including e.g. dimensional variations, variations in the control of the print heads, and variations in the visco-elastic properties of the ink, the size of image dots formed on the coated paper by the distinct print heads may vary yielding different values for output parameters of the respective print heads. In case of bi-directional printing for instance, such deviation may be caused by the different location of satellites on the image-receiving member when printing in the respective directions. For example, when printing from the left to the right satellites fall inside the main droplet on the paper, while when printing from the right to the left, the satellites fall outside the main droplet on the paper.

An example of an output parameter is the optical density (OD). The optical density is known to be correlated with dot size casu quo dot mass. The correlation is such that OD increases with increasing dot size. Measuring OD is therefore indicative for dot size variation. The respective patches printed by the respective print heads are scanned with a scanner in order to determine an OD value for each of the respective patches. The OD values are corrected such as to compensate for any deficiencies and/or dependencies introduced by the paper and/or the scanner. In this example the print head corresponding to the printed patch having the median OD value, is taken as the reference print head. The OD differences, i.e. the differences between each other of the OD values of the respective patches printed by the respective print heads and the median OD value, are calculated. When knowing the dependency of OD (see also fig.3) casu quo the dot mass (see also fig.4) from the temperature of the supporting substrate, the OD differences can be easily converted into temperature differences once the relationship between OD and the substrate temperature is determined (see also fig.5). The absolute value of each of the temperature differences is 15% of said predetermined substrate temperature value of 40 Centigrade degrees or less, or preferably 10% or less. Doing so enables to determine a target temperature value for each other of the

respective print heads by adding the associated calculated temperature difference to the predetermined substrate temperatur value of 40 Centigrade degrees. Alternatively in case the calculated temperature difference is more than the threshold value of 15% or 10% of said predetermined temperature value, then one may opt to replace said calculated temperature difference value by the threshold value. Subsequently the substrate temperature of each other of the print heads is adjusted to its associated target temperature value. By minimising the static temperature differences of multiple print heads of the same colour, the need for expensive dynamic temperature control means is obviated. Moreover, it is observed that when the (static) target temperature values of the respective print heads are within close range, each print head reacts substantially analogous when being subjected to dynamic temperature variations, such that variations in an output parameter which can be contributed to differences between the print heads are minimised resulting in an overall print quality improvement.

CLAIMS

1. A printing device having a plurality of print heads for image-wise forming dots of a marking substance on an image-receiving member, comprising:

a heat exchange device for bringing the temperature of each of said plurality of print heads to a predetermined temperature value, and

an adjustment device for adjusting the temperature of one or more of said plurality of print heads from its predetermined temperature value to an associated target temperature value,

characterised in that

each of said associated target temperature values is determined in relation to a target value of an output parameter of said print heads, said target value of said output parameter being determined on the basis of the respective values of said output parameter for the respective print heads, said respective values being obtained by operating each of said respective print heads at said predetermined temperature value to render a predetermined test pattern, where said target value of said output parameter is determined such that for each of the print heads the absolute value of the difference between said associated target temperature value and said predetermined temperature value with which the temperature of each print head is to be adjusted is 15% of said predetermined temperature value or less.

2. The printing device as recited in claim 1, wherein said absolute value with which the temperature of each print head is to be adjusted is 10% of said predetermined temperature value or less.

3. The printing device as recited in claim 1, wherein said target value of said output parameter is obtained by averaging said respective values of said output parameter for the respective print heads.

4. The printing device as recited in claim 1, wherein said target value of said output parameter is obtained by selecting the median value of said respective values of said output parameter for the respective print heads.

5. The printing device as recited in any preceding claim, comprising at least two print heads for image-wise forming dots of marking substance of the same colour.

6. The printing device as recited in claim 5, wherein said at least two print heads are positioned on a print carriage in a staggered configuration with respect to said scanning direction.

7. The printing device as recited in claims 1 to 4, comprising a first plurality of print heads for image-wise forming dots of a first colour and a second plurality of print heads for image-wise forming dots of a second colour different from said first colour, said first plurality of print heads having a corresponding first predetermined temperature value and a first target value of an output parameter, said second plurality of print heads having a corresponding second predetermined temperature value, different from said first temperature value and a second target value of an output parameter.

8. A method for controlling a printing device having a plurality of print heads for image-wise forming dots of a marking substance on an image-receiving member, comprising the steps of:

bringing the temperature of each of said plurality of print heads to a predetermined temperature value,

determining a target temperature value for one or more of said plurality of print heads, and

adjusting the temperature of one or more of said plurality of print heads from its predetermined temperature value to its associated target temperature value, characterised in that

each of said target temperature values is determined in relation to a target value of an output parameter of said print heads, said target value of said output parameter being determined on the basis of the respective values of said output parameter for the respective print heads, said respective values being obtained by operating each of said respective print heads at said predetermined temperature value to render the same image, where said target value of said output parameter is determined such that for each of the print heads the absolute value of the difference between said associated target temperature value and said predetermined temperature value with which the temperature of each print head is to be adjusted is 15% of said predetermined temperature value or less.

9. The method as recited in claim 8, wherein said target value of said output parameter

is obtained by averaging said respective values of said output parameter for the respective print heads.

10. The method as recited in claim 9, wherein a target temperature value for each of said plurality of print heads is determined, and the temperature of each of said plurality of print heads is adjusted from its predetermined temperature value to its associated target temperature value.

ABSTRACT

PRINTING DEVICE AND CONTROL METHOD THEREOF

A printing device having multiple print heads is disclosed, which obviates the need to dynamically control temperature differences between distinct print heads. The printing device is provided with a heat exchange device for bringing the temperature of each print head to a predetermined temperature value, and with an adjustment device for adjusting the temperature of one or more print heads from the predetermined temperature value to a static target temperature value. The target temperature values are determined in relation to an output parameter of the printing system such that a minimal adjustment is required.
Also disclosed a method for controlling a printing device.

(figure 5)

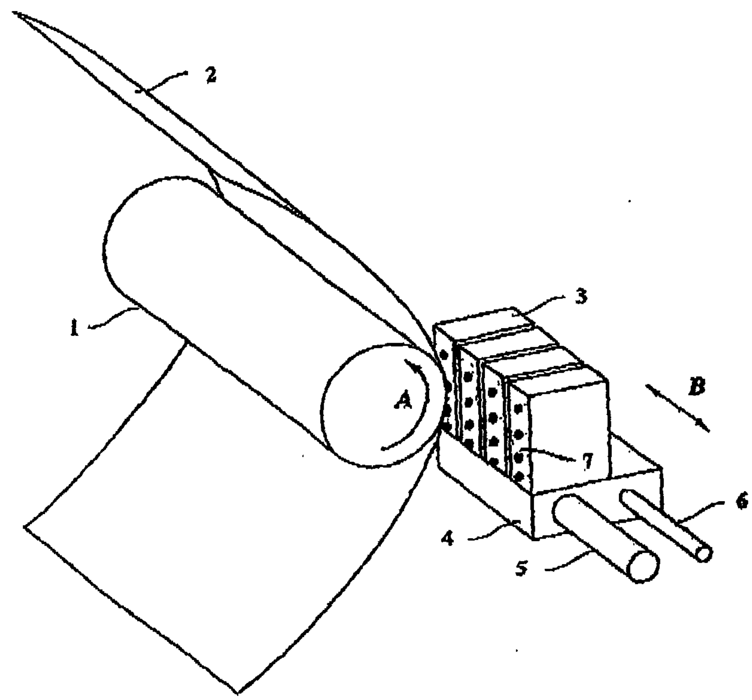


Fig.1

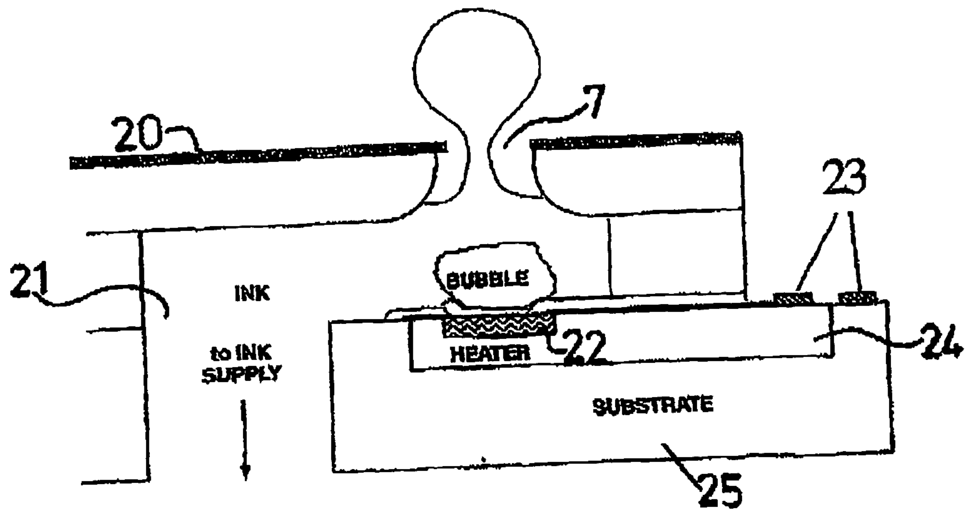
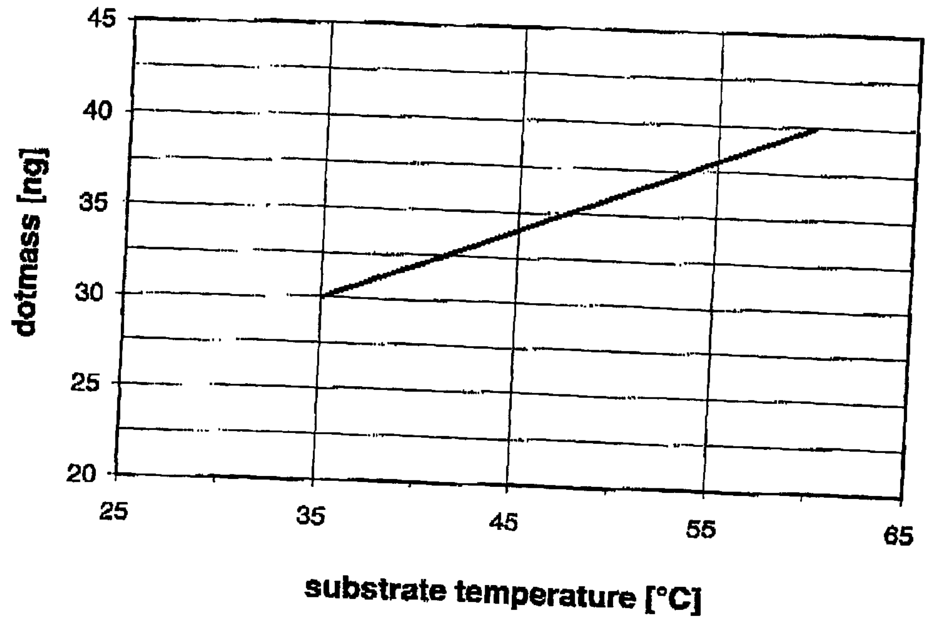


Fig.2

Fig.3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35
30
25
20
25
35
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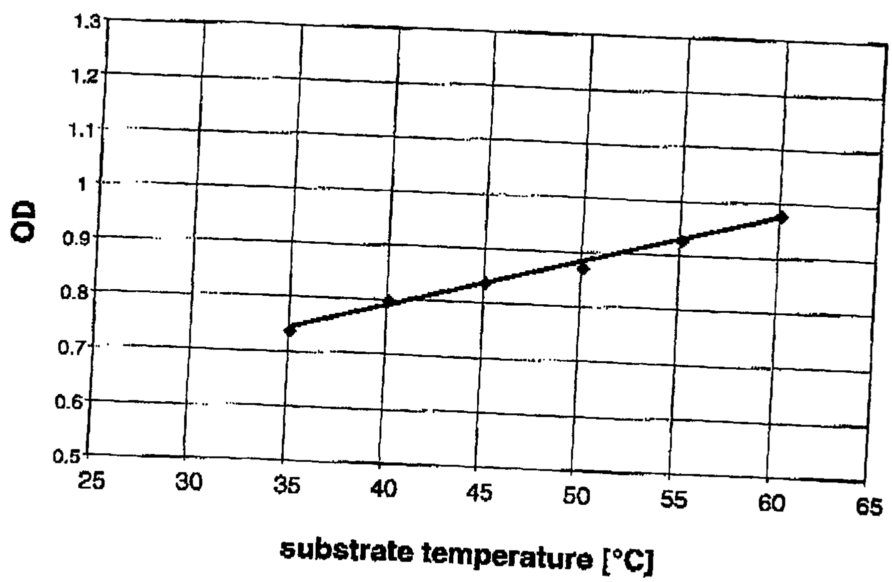
substrate temperature [°C]

Fig.4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1.1
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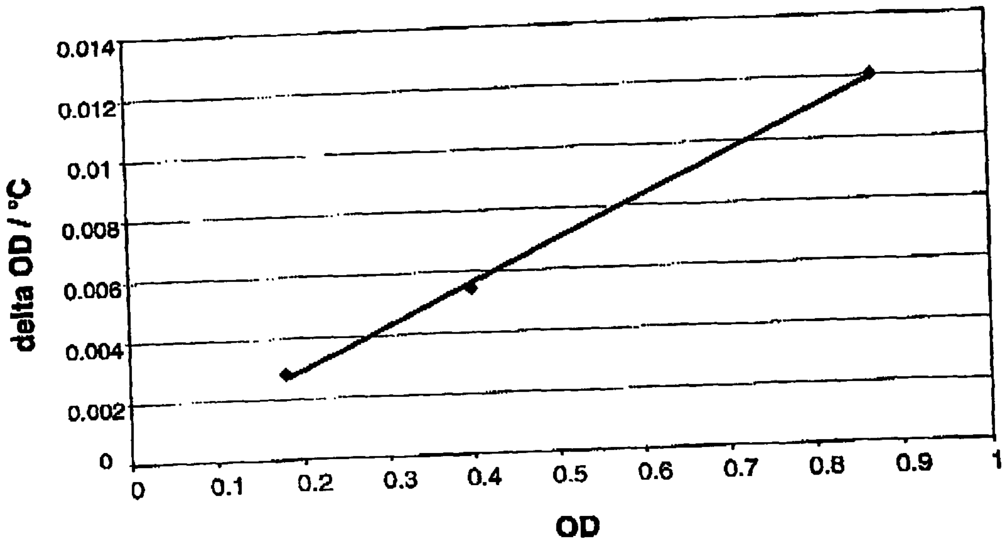
substrate temperature [°C]

Fig.5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